DOCUMENT RESUME

ED 334 463 CE 058 564

AUTHOR	Savage, Ernest, Ed.; Sterry, Leonard, Ed.
TITLE	A Conceptual Framework for Technology Education.
INSTITUTION	International Technology Education Association, Reston, VA.
SPONS AGENCY	Technical Foundation of America, Glen Ellyn, IL.
PUB DATE	90
NOTE	32p.
AVAILABLE FROM	International Technology Education Association, 1914 Association Drive, Reston, VA 22091 ($10.00 members; $12.50 nonmembers).
PUB TYPE	Viewpoints (Opinion/Position Papers, Essays, etc.) (120)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Curriculum Development; Educational Needs; Educational Practices; Education Work Relationship; Futures (of Society); Models; Problem Solving; Research Needs; *Science and Society; Science Education; Science Programs; Secondary Education; Technical Education; *Technological Advancement; *Technological Literacy; *Technology
IDENTIFIERS	*Technology Education

ABSTRACT

Based on the premise that technology is an integral part of society and culture, this guide provides an overview of technology and the process used to teach about it. It also presents a model for technology education, with implications and characteristics, along with a process model for the development of a technology education course of study. Challenges and recommendations to the profession are also stated. The paper is organized in five sections. The first section, an introduction to technology, discusses definitions and context of technology, the role of the individual in the social-technological environment, and the relationship of technology to other subjects. In section 2, the technological method model is outlined. Parts to be integrated into the model include terminology, resources, tools, materials, energy, time, communications, production, planning, organizing, and controlling. The third section presents a model for technology education, including its mission, goals, problems or opportunities, resources, assessment, and practical implications. Section 4 includes applications of the conceptual model, including how to use it to create a course of study. The final section includes challenges to the curriculum from the model, as well as recommendations and a proposed research agenda for technology education. (26 references) (KC)

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A CONCEPTUAL FRAMEWORK FOR TECHNOLOGY EDUCATION

Directed and Edited by:
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and
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INTERNATIONAL
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A
CONCEPTUAL FRAMEWORK
FOR
TECHNOLOGY EDUCATION

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ACKNOWLEDGEMENTS

This document is the result of significant work on the part of many organizations and individuals. The Technical Foundation of America provided the grant to bring the team and subgroups together numerous times. Their confidence that the process would result in a significant product provided the motivation for continued revision until a concensus was reached. The International Technology Education Association served as the fiscal agent and handled logistics. The trustees provided guidance and leadership from the initial selection of the team through the approval of the final product.

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We are most grateful to all who have contributed to the success of this project.

E. Savage, L. Sterry, Co-Directors

SECTION I
AN INTRODUCTION TO TECHNOLOGY

Overview

Throughout the history of civilization, the social fabric of humans and their enterprises has been interwoven with the thread of technology. Accordingly, young adults need to be familiar with technology and its dynamics, pervasiveness, and relationships to the society in which they will live and work (Johnson, 1989).

Technology is an integral part of our society and culture. Hardly a minute of the day goes by without our being influenced by technological products. Even while we sleep, we are surrounded by structures and devices that keep us warm and safe. The study of technology should be an interdisciplinary part of the education of all students.

This document provides an overview of technology and the process that is used to "do" technology. It also presents a model for technology education, with implications and characteristics of it, along with a process model for the development of a technology education course of study. Challenges and recommendations to the profession are also provided.

Definition of Technology

Technology is a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants.

Context of Technology and Society

Technology is an integral part of our social structure. This structure can be defined in part by its use of technology which transforms the environment, ideologies, and its sociological elements. It is this interaction, that is, the dependence of humans on technical means for survival, that warrants the study of technology by all people.

Survival of the human species has continuously relied on means to adapt to the natural environment. Humans, constrained by their biological inheritance, have been forced to utilize support mechanisms for their sheer survival. By creating technical means for this survival, humans were able to adapt both physically and socially. The acquisition of these technical means has been cumulative over the years with each new element adding to the existing inventory of knowledge. Archaeological evidence reveals the use of technical means in the past and it is obvious that our reliance on our technology has not diminished today. As a result, the nature of humans is expressed in cultural contrivances, both tangible (e.g., tools, machines) and intangible (e.g., ways of thinking).

One of the major contributors to the uniqueness of our culture over the last quarter century is the scope and pace of technological change. Since we do not inherit culture through genetic transformation, we must rely on our exposure to information. In this way, culture is learned. Understanding and coping with technology was relatively easy decades ago. However, today, making sense of culture on a global basis is a difficult task due to the avalanche of inventions and innovations.

A society is a group of people working as a cohesive unit bound together by its culture. Within society is the human endeavor called technology. Therefore, it is the human who conceives what should be developed, and it is the human who should control its destiny. One significant challenge is to ensure that technical means are used appropriately for the welfare of all people without damaging the natural environment. It is imperative, therefore, that information be available for all people—information that is accurate and usable. The primary vehicle for this dissemination is the educational enterprise. Just as society advances technologically, so must its educational system, thus enabling individuals to make a commitment to generating a society and environment that are humane and controlled for the betterment of humankind.

Technology in a Global Society

The massive growth of technology and technology transfer has introduced us to the realities of an interdependent world. Global culture has moved within the past decade from self-sufficient economies to an integrated system of global production.

The use of technology is a global phenomenon with no country immune to the need for extending the potential of the human being. While not all countries have developed equally in a technological sense, it is clear that today new technologies will develop where human resources and commitment exist. No longer is the greatest asset capital or natural resources, but rather the ability to use information. Information is one of the most useful resources in developing and managing technological systems. Countries who have access to and can manage technical information have a definite competitive edge in the worldwide marketplace. As a result, the demand for more innovations and inventions related to technology will continue to increase on a global scale.

Technological advancement, however, increases the demand for finite natural resources, compounding the problems of our planet. New transformations, prompted by technological growth, will come in shorter periods of time and will be more potent than ever before, while providing both social dissonance and opportunity.

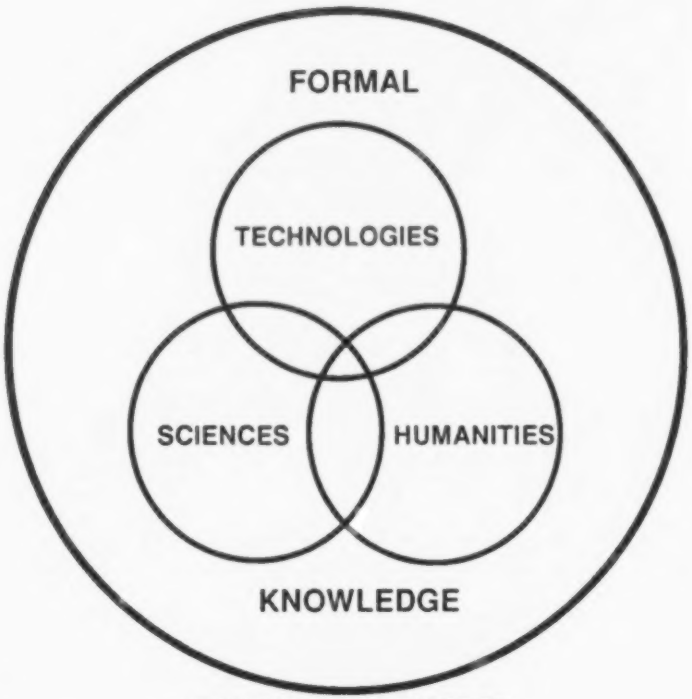
The human race cannot look only to history to guide it through future unprecedented problems and opportunities. We must look to technology for more answers. Technology is a product of human effort; therefore, it must be carefully designed and utilized so that all cultures may benefit. This must be done with a global view, in order to maintain a balance of the systems which sustain the human race. Hence, technological literacy should be a mandate in all cultures.

Domains of Knowledge

In the early 1980's, the *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hales, 1981) identified a base for curriculum derivation. Many of those concepts have been incorporated into the foundation of this document, especially the perspective on the relationship between the domains of knowledge and the human adaptive systems.

Scholars have identified knowledge which enables humans to adapt to their environment. This prospective knowledge gives people an understanding of what was, what is, and what can be. It is provided with a syntactical and conceptual structure into bodies of knowledge known as domains. Four major cultural universals or domains for providing a cognitive base for human adaptation in the natural environment are the (1) sciences, (2) humanities, (3) technologies, and (4) formal knowledge. These four domains are intrinsically linked, with the fourth, formal knowledge, being represented by language, linguistics, mathematics, and logic. Formal knowledge is separate, yet provides form and structure for the other three domains (See Figure 1–1).

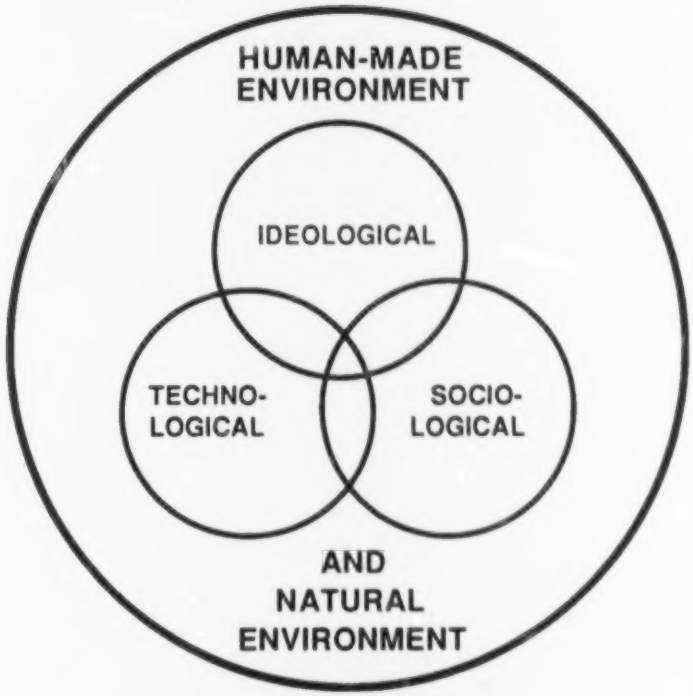
Each domain has its unique purpose, knowledge base, and structure (Snyder & Hales, 1981). The technologies domain of knowledge contains all recorded knowledge relating to the types of technology. Similarly, the sciences and humanities domains of knowledge contain all recorded knowledge of the sciences and humanities, respectively.



DOMAINS OF KNOWLEDGE
FIGURE 1-1

Human Adaptive Systems

Technology as a human endeavor can be understood by analyzing the three human adaptive systems: (1) technological, (2) sociological, and (3) ideological. Technological human adaptive systems pertain to technical means of manipulating the physical world to meet human needs and wants. Sociological systems are patterns of societal endeavor, characterized by social organization and regulation. Ideological systems are concerned with the values and beliefs of society. The three human adaptive systems, as presented in the *Jackson's Mill Industrial Arts Curriculum Theory* (shown in Figure 1–2), are interrelated and exist within the human-made and natural environments (Snyder & Hales, 1981).



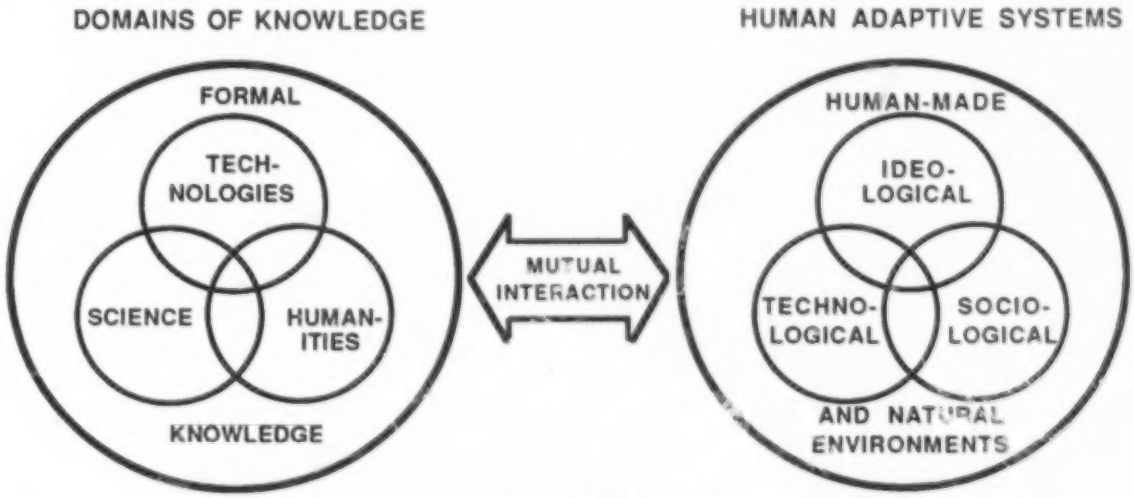
HUMAN ADAPTIVE SYSTEMS
FIGURE 1–2

Interaction of the Domains of Knowledge and Human Adaptive Systems

The human adaptive systems mutually interact with the domains of knowledge and contribute to each other (see Figure 1–3). As people develop better and approved ways to adapt, the results contribute to the domains of knowledge. The adaptive systems utilize knowledge processes to create new knowledge (Snyder & Hales, 1981) by calling upon appropriate quantities of technological knowledge usually through a systematic process. Any new knowledge produced as a result of this interaction becomes part of the body of knowledge of technology.

As previously noted, technology exists as a domain of knowledge which gives people an understanding of what it was, is, and can be. The application of technology in a human adaptive system involves people applying technological knowledge and other resources in a social/cultural context through technical processes and systems to produce outcomes in response to human wants and needs. Technology, as a human adaptive system, interacts with the other two human adaptive systems: ideology and sociology. As a result, technological outcomes have an impact on people, society, culture, and the environment which must be assessed and understood. Hence, the other adaptive systems are affected by, and are used to evaluate, technology. Also, the improved ways to create, implement, assess, and manage technology contribute to the domains of knowledge.

Technology has an effect on people's values, which must be considered in the assessment and shaping of technology in a global society. This interaction must be understood and practiced within the human adaptive systems in order to use and control technology effectively.



MUTUAL INTERACTIVE MODEL
FIGURE 1–3

Role of the Individual in a Socio-Technological Environment

The individual in today's world faces unprecedented change which requires the ability to continually cope and adjust. The inability to make these adjustments can cause individuals to be out of harmony with the very technology they worked to create and maintain. Technology has the potential to threaten and alter our cultural mores and customs, as well as our views of ourselves.

An understanding of technology can allow individuals to cope with, adjust to, invent, and innovate in this technological world. Literally, ignorance of how technological systems are designed and function leads to inadequacy and a lack of productivity. These traits limit one's ability to function as a consumer, producer, decision-maker, worker and planner.

Survival of the human race and its natural environment relies on individuals who: (1) see themselves intrinsically involved in nature, (2) do not deny that there are problems created by technology and are willing to consciously add to the solution, (3) do not see themselves as a single entity, but rather as part of an interdependent world, and (4) realize that there is a pattern ofrelationships that provides opportunity for individuals in a technological society.

Attributes of Technology

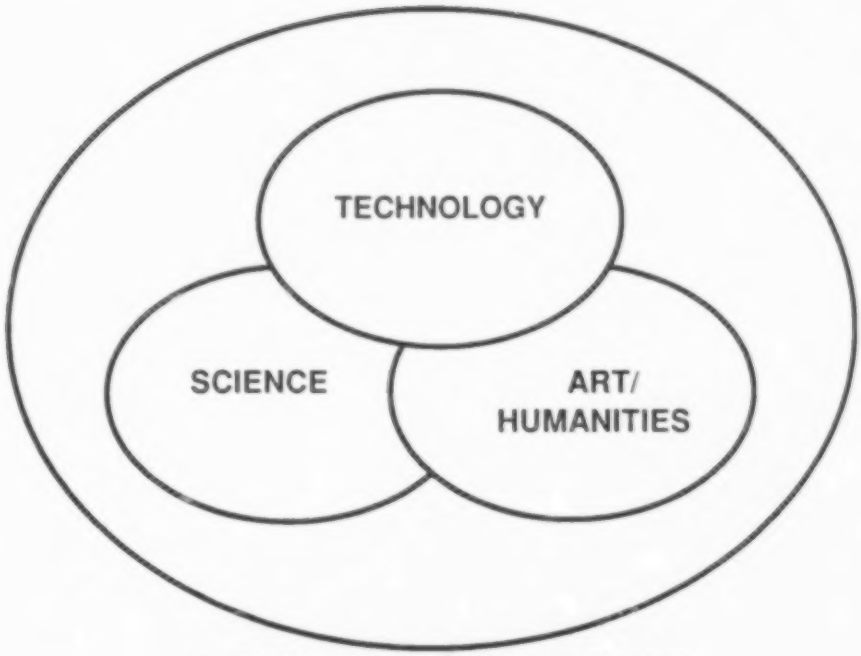
The study of technology over time has resulted in the identification of universal attributes. They are:

- People create technology.
- Technology responds to human wants and needs.
- People use technology.
- Technology involves actions to extend human potential.
- The application of technology involves creating, implementing, assessing, and managing.
- Technology is implemented through the interaction of resources and systems.
- Technology exists in a social/cultural setting.
- Technology affects and is affected by the environment.
- Technology affects and is affected by people, society, and culture.
- Technology shapes and is shaped by values.

Relationship to Other Bodies of Knowledge

Bodies of knowledge are often grouped into broad categories according to the nature of their content and methods. In this respect, each body of knowledge occupies a unique and equivalent position.

Furthermore, bodies of knowledge are interrelated (Zuga, 1988; see Figure 1–4). Each contributes methods and content useful to others. For example, human values, behavior patterns and aesthetics (humanities/arts) facilitate and constrain technology. Scientific theory and practice (science) contribute to technological methodology. Communities of technologists (technology) actively incorporate this knowledge in solving problems. Bodies of knowledge have distinguishing features as represented in Figure 1–5.



RELATIONSHIPS OF BODIES OF KNOWLEDGE
FIGURE 1–4

Communities of practitioners have unique methods of generating new knowledge. Although there is more consensus about methods among some practitioners than others, each has methods which are peculiar to its problems and opportunities. For example, the primary research paradigm among scientists is the Scientific Method, which includes a problem statement, careful observation, the statement of hypothesis, testing, and theory generation. Most social scientists in the humanities share the same positivist methodological orientation as natural scientists. However, there is still considerable degree of flexibility, including the widespread use of methods derived from phenomenology and critical science, due to the nature of what is studied—human behavior. The primary method of knowing for technologists is a problem-centered approach, governed by human needs and wants, called the Technological Method. Technologists' activity is based on the pragmatic desire or need to solve human problems.

	TECHNOLOGY	SCIENCE	HUMANITIES/ ARTS
DEFINITION	STUDY OF THE HUMAN MADE WORLD	STUDY OF THE NATURAL WORLD	STUDY OF VALUE STUDY OF HUMAN BEHAVIORS
METHOD OF INQUIRY	TECHNOLOGICAL METHOD	SCIENTIFIC METHOD	ECLECTIC METHOD SCIENTIFIC PHENOMONOLOGICAL CRITICAL SCIENCE METHODS
CONTENT EXAMPLES	BIO RELATED COMMUNICATION PRODUCTION TRANSPORTATION ETC.	BIOLOGY CHEMISTRY PHYSICS MATH ETC.	HISTORY PHILOSOPHY LANGUAGE SOCIOLOGY ANTHROPOLOGY PSYCHOLOGY ETC.

FEATURES OF BODIES OF KNOWLEDGE
FIGURE 1–5

SECTION II
THE TECHNOLOGICAL METHOD MODEL

Introduction

The Technological Method Model is presented in Figure 2–1. This model graphically displays the essential model for "doing" technology, as well as for contributing to the body of knowledge about technology. It is, therefore, a theory and practice model. This model can be used at the personal, organizational, institutional, or global levels; it identifies a means for engaging in individual or collective technological action.

Technological practice is most often driven by humans who are confronted with problems and/or opportunities. Utilizing the problem solving method, humans draw upon technological processes and resources to achieve meaningful outcomes. These outcomes result in consequences which may be either desirable or undesirable. As a result, technological practice has to be properly managed and assessed. Feedback is the mechanism whereby technological practice is managed and assessed. The nature of feedback is graphically displayed in the model presented in Figure 2–1 by arrows which show the interactive relationships of the various elements.

Even though figure 2–1 shows one microcosm of technological practice, it must be realized that outcomes generally lead to additional/new problems and/or opportunities which in turn may lead to new technological practices. The evolution of technology involves the continual interaction of models such as these, often interconnected one to another.

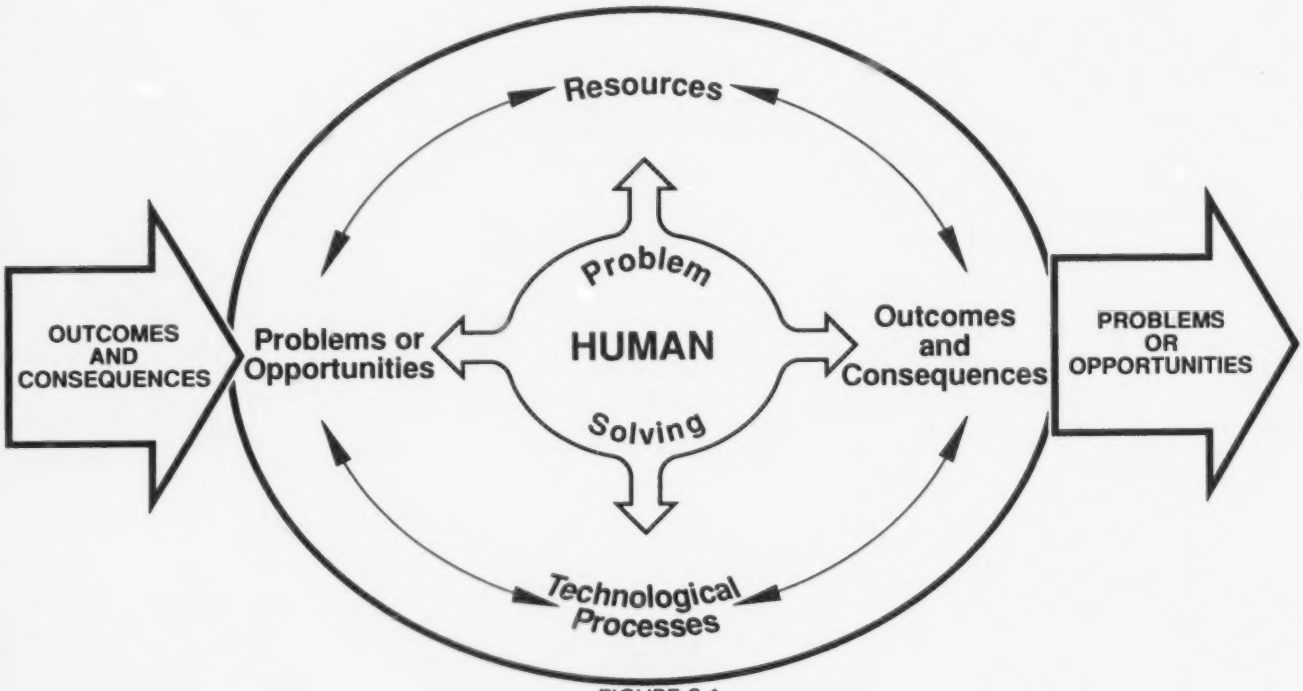


FIGURE 2-1
THE TECHNOLOGICAL METHOD MODEL

TERMINOLOGY FOR THE TECHNOLOGICAL METHOD

HUMANS
Needs
Wants

CHALLENGES
Problems
Opportunities

PROBLEM SOLVING
Defining the Problem
Developing Alternate Solutions
Selecting a Solution
Implementing and Evaluating the Solution
Redesigning the Solution
Interpreting the Solution

RESOURCES
People
Tools/Machines
Information
Materials
Energy
Capital
Time

TECHNOLOGICAL PROCESSES
Bio-related Technology Processes
Communication Technology Processes
Production Technology Processes
Transportation Technology Processes

ACCOMPLISHMENTS
Consequences
Outcomes

An Overview of the Technological Method Model

The basic topical elements of the Technological Method Model are shown below. The following sections describe what each element is and its function in the model.

Humankind and Problem Solving

Human beings stand at the pinnacle of all living things. They take this position because of their complexity. This makes humans not better than other life forms, but simply capable of a greater range and complexity of behaviors. It is the human brain that identifies the single most important difference between humans and other organisms. That brain enables people to think, to store huge quantities of information available for retrieval at a moment's notice, and to fashion cognitive strategies that lead to survival, and to create conditions for a better life, represented by such things as better health, greater wealth, improved housing, or more nutritious foodstuffs—to mention but a few.

Human beings, and the culture they create, seem to run counter to the principle of entropy—the tendency for things to gravitate toward disorder or randomness. In contrast, humankind creates order, structure, and consistency in all of its endeavors.

Order, structure, and consistency are both good and bad. They are good in the sense that they enable people to live in a predictable world and also to behave consistently. They are bad

in that they make change and adaptation to new situations somewhat difficult. It is this very aspect of human traits that makes it necessary for people to be adept at problem solving. The more skilled humans are at problem solving, the better the possibility of adjustment to their world.

Problem solving is a thinking skill and reaches its very highest form in humans. The ability to solve problems is at the root of technology, for as human needs or wants emerge they are satisfied by those cognitive strategies known as problem solving. The process of problem solving provides the parallel in technology to the scientific method in science.

Problem solving has been recognized for a long time as having significance in human learning and adaptation. Aristotle was one of the first to comment on the importance of solving problems. In more recent times, John Dewey wrote extensively on the nature of problem identification and problem solving. However, it was George Polya, a mathematician, who, in the 1950's, first devised a schema for solving problems. His was a four step process involving understanding the problem, devising a plan for solving the problem, carrying out the plan, and looking back. Since Polya's work focused on mathematics, it does not address the fabrication and testing of appraratus (technical means) which is the element that separates technology from other human activities. Therefore, a more complete model for technological problem solving might include the following six steps which have been generalized from the work of several scholars (Waetjen, 1989; Hutchinson, 1987; Barnes, 1989):

1. Defining the problem: Analyzing, gathering information, and establishing limitations that will isolate and identify the need or opportunity.
2. Developing alternate solutions: Using principles, ideation, and brainstorming to develop alternate ways to meet the opportunity or solve the problem.
3. Selecting a solution: Selecting the most plausible solution by identifying, modifying, and/or combining ideas from the group of possible solutions.
4. Implementing and evaluating the solution: Modeling, operating, and assessing the effectiveness of the selected solution.
5. Redesigning the solution: Incorporating improvements into the design of the solution that address needs identified during the evaluation phase.
6. Interpreting the solution: Synthesizing and communicating the characteristics and operating parameters of the solution.

Problems/Opportunities

Human wants and needs lead to the identification of technological problems and opportunities. Problems are questions or matters involving doubt, uncertainty, or difficulty. They deal with choices of action which might ameliorate unsatisfied human needs and wants. Opportunities, on the other hand, are future-oriented. That is, they can be planned and, in fact, created.

Types of Problems and Opportunities

Problems facing humans involve personal, social, and environmental issues. Solutions to these problems may utilize technological, social, and educational means (see Table 2–1).

TYPES OF PROBLEMS	TYPES OF OUTCOMES		
	Technological	Social	Educational
Personal (e.g., loss of vision)	contact lenses	affordable medical care	effect of looking directly at sun
Social (e.g., food for the masses)	chemical herbicides and pesticides	world hunger crusade	awareness of situation in other nations
Environmental (e.g., clean energy)	solar panel	legislation (e.g., clean air act)	need to recycle

TYPES OF PROBLEMS & OUTCOMES
TABLE 2–1

Resources

Resources are needed to accomplish technological ends. They are people, tools/machines, information, materials, energy, capital, and time. The use of these resources must be optimized to ensure efficiency and renewability where appropriate. Constraints must be considered, taking into account physical limitations and regulation.

People

The problems, needs, and opportunities perceived by people stimulate the development of technology. People design and create technology by combining previous knowledge with new ideas. People make policy decisions that promote or constrain technological research, development, and growth. People also provide the labor upon which some industries depend. Finally, people are consumers and users of the products and services of technology. People, using tools and machines, direct and control the processing of materials, energy, and information as the basic resources of technology.

Tools/Machines

Tools, including hand tools and machines, provide the means for humans to process and change the basic resources of materials, energy, and information. As we seek to employ tools in the technological process, we must consider constraints such as availability, access, or whether suitable tools have yet been invented to undertake the desired processes.

Information

Technology has developed rapidly because of the information explosion. The first of these explosions, represented by the production of books using the printing press, laid the foundation for the technological upheaval that started in the Middle Ages and culminated in the Industrial Revolution. Information in this form was largely symbolic and static. During the past few decades there has been a new information explosion resulting in a doubling of technological information every five years. Information has taken on more dynamic forms, such as signals that can be transmitted electronically for purposes of communication or control. The ever-increasing information base must be effectively managed.

Materials

Materials represent the physical entities from which technological devices, structures, and systems are made. Materials come in natural and synthetic forms. Synthetic or manufactured materials far outnumber the relatively few raw materials that serve as natural resources for the finished products and artifacts of technology. Raw materials can be classified as renewable or nonrenewable. Synthetic materials can be developed (engineered) to fit specific requirements and provide improved properties and characteristics. As we are constrained by our limited resources, we must ensure that the development of new synthetic products is controlled.

Energy

Energy creates the power to drive tools and machines, to process materials into manufactured products and to create structures. Power can be generated from selected nonrenewable energy sources such as coal, oil, and gas. Energy can also be converted back and forth into different forms, such as chemical, thermal, light, and sound. It can also be converted into useful electrical, fluid, and mechanical power in response to the demands of an identified problem. Energy forms found naturally, such as solar, gravitational, and geothermal provide the capability for renewable energy. Proper management of energy resources is essential to world market competition success.

Capital

Any form of wealth (e.g., shares of stocks, cash, land, buildings, equipment) is a capital resource. Modern technological enterprise rests upon the use of large amounts of capital, such as sophisticated machinery and equipment, large scale production and storage facilities, and stores and stocks of finished and unfinished material.

Time

In prehistoric eras, time was measured in periods based upon the rising and setting of the sun. In the agricultural era, time was measured in days and seasons. In the industrial era, time was measured in terms of hours, minutes, and seconds. In the information era, time is measured in terms of smaller and smaller fractions of a second. Time represents an essential resource when all the other resources are brought together to support a process. Processes, as sequences of actions and change that yield results, require time.

Major Areas of Technological Process

Throughout history, people have employed technological systems as the means to adapt the environment to human needs and wants. Our technological world can be viewed from many perspectives. Swyt (1987), identifies the content of technology as physical, including motion, power and work; material, representing matter in non-life forms; information, such as data, information, and knowledge; and bio, relating to biologically-active agents. The Chicago Museum of Science and Industry classifies technology as the Physical World, the Information World, and the Living World. This document addresses technology through the content reservoirs of Bio-related Technology, Communication Technology, Production Technology, and Transportation Technology.

Each of these major systems is basic to every society. Bio-related technologies provide the means to preserve and process food, propagate plants and animals, diagnose and treat medical disorders, and most recently, to synthesize vaccines and to engineer genetically life forms. Communication technologies enable us to process data and information into forms that are meaningful to humans. Production technologies, which include Manufacturing and Construction, assist people to create products or structures in a factory, workshop, or on site. Transportation technologies provide the means to move people and goods from one location to another through the air, across water, over land, and in space.

Technological Process

When humans are engaged in technological practice, they utilize technological processes in an ordered way to produce technological outcomes. Each major area of technology (Bio-related, Communication, Production, Transportation) has within it unique processes which are used to convert forms of matter, energy, and information into other forms.

Bio-related Technology applies biological organisms to make or modify products. The system includes the production process techniques relating to the products of agriculture, medical technology, and the biological processes tied to fuel and material production. Proper management of these techniques can result in a higher quality of life for all members of our global society. Mismanagement or misunderstanding can result in serious damage to ourselves and our environment.

Following are the process techniques of bio-related technology:

Propagating—To develop a living entity. The implications in the health and agriculture fields are obvious with respect to humans and animals. Fermentation and protein applications in foods, beverages, and materials also apply.

Growing—To develop living things or increase them in size, by synthesis, intake, or manufacture. Humans, plants, and animals are all "growth monitored." Crystal manufacture for the electronic industry also applies.

Maintaining—To support normal conditions for healthy existance. The need for sufficient nutrition and an appropriate environment are essential for the success of this process.

Harvesting—To gather and store entities. In the clinical sense, this technique relates to "giving birth" in human and animal entities, as well as accumulating products of agricultural and bio-process manufacture.

Adapting—To adjust to a change in the environment. This is the essence of technology; to adapt to our natural environment. Through processes of protection, enhancement, management, and development, people in health care and services, agriculture, food and material production, waste management, and regulation have enabled and, at times, directed our adaptation to our environment.

Treating—To apply a specific procedure to cure or correct a disease or pathological condition. When the human, plant, or animal output is improper, the necessary corrective measures must be taken. This is also true for materials in cases such as oil spills.

Converting—To change into something of different form or property. Experiments across species, such as combining potatoes with algae to produce a more nutritious product, are common today.

Communication Technology focuses on the processes and techniques of encoding, transmitting, receiving, storing, retrieving, and decoding graphic and electronic messages. Our global society is interconnected with communication networks that are superior to any communication system in the past. Systems of the past and present, as well as models of futuristic communication systems, should be studied to allow students to develop an understanding of how they work, why we depend on them, and how they can be improved.

The following are the process techniques of communication technology:

Encoding—To recode or modify information into a desired format or pattern for a specific method of transmission or storage.

Transmitting—To convey information from one location to another.

Receiving—To recognize and accept information that has been transmitted.

Storing—To record and file information for use at a later time.

Retrieving—To recall information from a stored condition.

Decoding—To convert recoded or modified information into an acceptable format for use.

Production Technology uses technological means to construct resources into goods, standard stocks, and structures. It includes content used to perform processing, constructing, and manufacturing operations. Production technologies are used to prepare or modify material resources by mechanical or chemical means so they become direct consumer products or serve as standard stocks for further production, communication, or bio-related operations. The outputs of production technologies include food, chemicals, power, and standard stocks, among others.

The following are the process techniques for production technology:

Primary Processing— To transform natural or raw materials into products, including mining, extracting, refining, lumbering, and farming.

Constructing— To produce goods to fill society's living, working, and transportation needs (e.g., homes, buildings, bridges, railways, roads, tunnels, canals, and dams).

Manufacturing—To convert materials into useful products.

Maintaining—To create services of economic value, including maintenance, repair, and education, through the use of human resources.

Transportation Technology is used to move people and products within a society. Transportation technology addresses four domains: terrestrial, marine, atmosphere, and space. Transportation options in a society can create opportunities for technological and cultural growth by enhancing mobility and providing product accessibility.

Following are the process techniques for transportation technology:

Receiving—To acquire people, materials, and goods at a terminal, station, or random or fixed points.

Holding/Storing—To reserve a facility for personalized and mass transit, or for materials/goods warehousing.

Loading—To put or place people and/or products in or on a transportation device or vehicle.

Moving—To change the position of goods and/or people from one point to another, using some transportation device or vehicle.

Unloading—To remove passengers and/or products from a transportation device or vehicle.

Delivering—To take people and/or products to their intended destinations.

Outcomes and Consequences

The ultimate outcome of any technological practice is the solution derived from the problem solving activity undertaken by humans. An outcome may solve one problem or respond to one opportunity, while at the same time creating others. One method for judging the appropriateness of the outcome is that human wants and needs should have been satisfied.

Outcomes have consequences which may impact humans, their social, economic, and political systems, and their environment. Impacts and consequences may be viewed as both positive and negative, planned and unplanned, and immediate and delayed.

The results of implementing technology need to be assessed to determine their impacts on people and the environment. The perceptional approach involves identifying the impact of a technological venture on society and culture using a desired or given standard for making a judgement which results in projecting and/or evaluating the impacts. Actions can then be taken to resolve any unexpected benefits, unexpected costs, and unexpected risks. Assessment might include either monitoring the process or evaluating a product after it has been implemented. In either case, anticipating impacts is important as a technology is being advanced.

The assessment of technology should examine the potential risks to humans if the technology is allowed to enter full scale development and production. Assessment tools may take the form of:

TREND ANALYSIS	Studying information about the past and present
TREND EXTRAPOLATION	Projecting or forecasting based on trend analyses
CROSS IMPACT ANALYSIS	Examining the relationship between trends
DELPHI PROCESS	Systematically collecting expert opinion
SCENARIO DEVELOPMENT	Creating an image of the future based on analyses, extrapolation, and expert opinion
TECHNOLOGY ASSESSMENT	Making informed judgments about technology before it is widely applied

The key questions concerning any proposed new technology should include the following:

1. What are alternative ways to accomplish the same ends? What trade-offs would be necessary between positive and negative side effects of each?
2. What will the proposed new technology cost to build and operate? How does that compare to the cost of alternatives? What will the social costs be?
3. What risks are associated with the proposed technology? What risks will the technology present to other species of life and to the environment?
4. What people, materials, tools, and knowledge will be needed to build, install, and operate the proposed new technology?
5. What will be done to dispose safely of the new technology's waste materials?

The technological environment is a product of resources and technological processes. To study resources without technological impacts would present an unbalanced view of technology. Therefore, as is done with the resources, technological impacts must be considered as each unit is studied. In the personal arena, such areas as values, ethics, norms, and psychological (including techno-fears and techno-phobia) and physical influences should be studied and analyzed for decision making and problem solving. Environmentally, presentation of the impacts of technology should be sensitive to the ecological systems of water, space, land, and air. Socially, technology also affects the basic institutions of family, religion, government, education and industry. Impacts and solutions should be viewed from positive and negative, planned and unplanned, and immediate and delayed consequences.

Combining Process Organizers

The technological process organizers provide a focus for specific human endeavors. Each of the four organizers is sufficiently broad to generate a body of knowledge. Based upon an identified problem, the organizers can be viewed as independent. For example, simple problems may only require information from one organizer for its solution. In addition, content may also be selected from two, three, or all four of the organizers to perform integrated technology functions using the technological method. For example, in extracting content for a more complex problem, knowledge may be selected from both communications and transportation. Furthermore, in certain more complex problems, data (knowledge), concepts, etc. may be taken from bio-related, communication, and production processes. Finally, in the most complex of problems, information will probably need to be taken from all four organizers of technological process.

Managing Technology

Effective management requires the wise manipulation of a number of variables. In short, one must determine "what can be done" tempered by the knowledge of "what should be done." Management permeates technological practice; all phases are managed for efficiency and effectiveness. Management functions include planning, organizing, actuating, and controlling.

Planning. Planning requires the ability to formulate, research, design, and engineer. Planning requires a response to the following questions: What is to be done? Where will it be done? When will it be done? How will it be done?

Organizing. Organizing requires the ability to structure and supply. Key organizing questions address: Who is to do what? How much authority does the individual or group have? Under what constraints will the individual function? The development of job descriptions and job specifications are appropriate organizing functions.

Actuating. Actuating, or directing, requires the ability to motivate, supervise, and coordinate. The key actuating question may be, "How can an individual be motivated to perform willingly and with enthusiastic cooperation?" Clarification of assignments, guidance in performance improvements, and encouragement are appropriate directing functions.

Controlling. The ability to control technological actions requires skills to monitor, report, and correct. Is the work being carried out properly? If not, what corrective measures are appropriate?

We have brought the earth to a point where our future well-being will depend heavily on how we develop, use, and restrict technology. In turn, that will depend heavily on how well we understand technological practice and the social, cultural, economic, and ecological systems within which we live.

SECTION III
A MODEL FOR TECHNOLOGY EDUCATION

Technology Education

Technology has been defined as a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants. Technology education must allow individuals to understand technology in the context of the world in which they live and interact. Therefore, technology education is the study of technology and its effect on individuals, society, and civilization.

Mission

As technological development continues to accelerate, it can either become increasingly difficult for people to understand and use, or it can become "user friendly." It is necessary for all people to understand technology if they are to function effectively in their roles of consumers, voters, workers, employers, and family members. Therefore, it is important that the technology program be responsive to the demands of society. To accomplish this, the study of technology should be a part of the learning experiences of all students, in order that they may better understand, learn to control, and effectively participate in their environment. Hence, the mission of technology education is to prepare individuals to comprehend and contribute to a technologically-based society.

Goals

Students, as a part of total education, will become technologically literate and capable by:

1. Utilizing technology to solve problems or meet opportunities to satisfy human needs and wants.
2. Recognizing that problems and opportunities exist that relate to and often can be addressed by technology.
3. Identifying, selecting, and using resources to create technology for human purposes.
4. Identifying, selecting, and efficiently using appropriate technological knowledge, resources, and processes to satisfy human wants and needs.
5. Evaluating technological ventures according to their positive and negative, planned and unplanned, and immediate and delayed consequences.

Technology Education Model

The Technological Method Model provides a framework for teaching technology. That is, it provides the framework for the immersion of students in actual technological practice. As such, in its educational counterpart, the Model for Technology Education (Figure 3–1), students will identify problems or opportunities utilizing the problem solving method, selecting the appropriate resources and employing technological processes to produce outcomes for which they will assess the consequences. In effect, to teach technology, students must "do" technology which translates into involving students in each element in the Model for Technology Education and in the interactive nature of the Model.

Applying Human Direction

Human needs and wants must be satisfied in the context of productive citizenship. According to Stevens (1986), among the things implied by productive citizenship, in addition to occupational competence, are a well developed value system compatible with the workings of society, a sense of responsibility to humankind, the ability to make decisions tempered with a sense of what is right, as well as what is possible, a healthy self-concept, the capacity for independent thought, and the ability to communicate effectively and efficiently.

As people develop from childhood to adulthood, they experience technology at varying levels and for different reasons. As a result, levels of competence are expanded, but in different ways. For the young child, learning is often informal learning in the home; but early learnings have great permanence. During adolescence, learning occurs in a more formal, structured environment namely, in the school. This is where technology is studied in an organized fashion. As we reach adulthood, schools, colleges and universities provide theory and practice needed to meet responsibilities encountered in the work place. In fact, at this level individuals, themselves, often contribute to the overall technological body of knowledge.

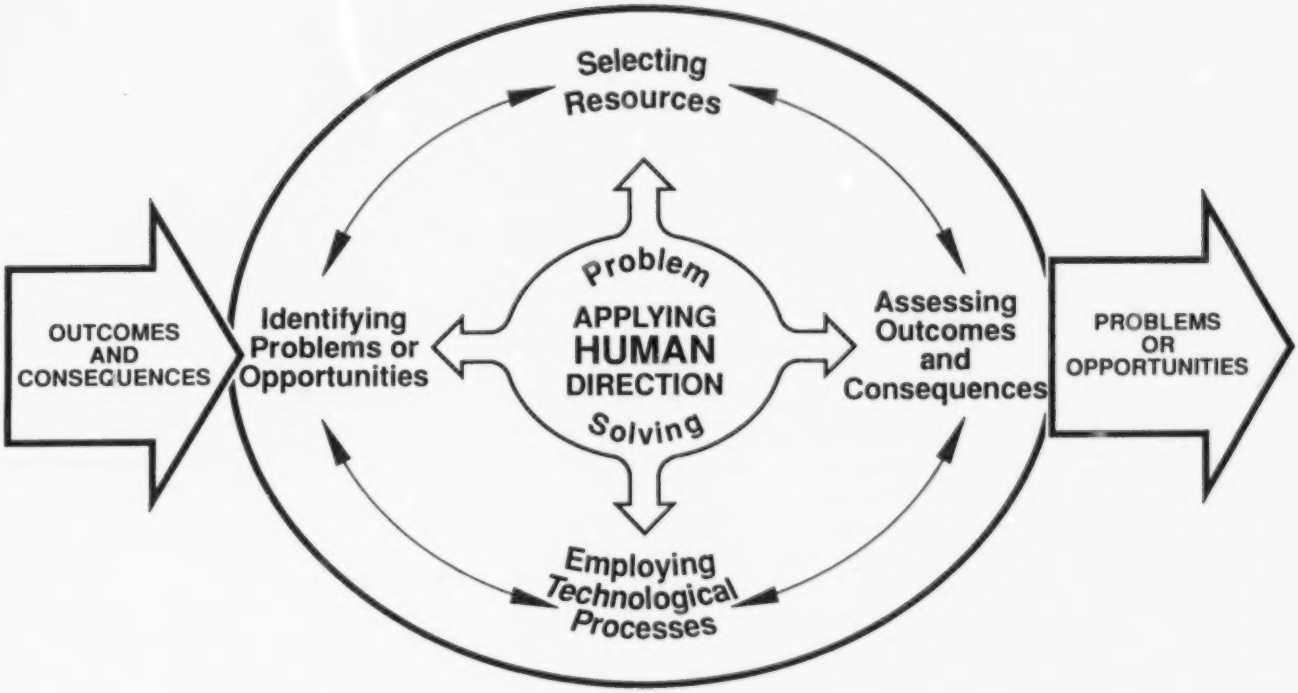


FIGURE 3-1
A MODEL FOR TECHNOLOGY EDUCATION

Identifying Problems or Opportunities

An important element of attacking a problem or addressing an opportunity is to ensure that students "own" the problem (i.e., they understand it and it is placed in the proper context which has relevance to them). Students must grasp the full meaning of the problem and begin to understand how to solve it; this can be accomplished through problem definition or goal setting.

Selecting Resources

Students must understand how all resources influence the selection of an optimum solution to any technological problem. Proper management of technological ventures cannot occur without viewing the limitations, restrictions, capabilities and accessibility of people, tools/machines, information, materials, energy, capital, and time. Constraints, or identified limitations, become a significant part of resource management (these might include limited materials, finances, or time). The laws of nature also provide constraints and preclude implementation of certain solutions.

Employing Technological Processes

To transform resources into technological outcomes, students should be able to select and implement appropriate technological processes. Students should develop skill in safely using tools and machines to process energy, materials, and information. In employing technological processes, students should be aware of the following considerations:

1. Appropriateness of process. Does the product or process make efficient use of the resources?
2. Appropriateness to goal. Does the process chosen support the goals of individuals, societies, or the enterprise?
3. Cultural and environmental appropriateness. Are the processes compatible with the local environmental and cultural setting?

Assessing Outcomes and Consequences

As the outcomes of technological ventures occur, students must study the impact that each outcome will have within the historical, cultural and environmental contexts. For example, the instructor could consider the use of energy as part of a unit of study for almost all technologies because energy is used or created using technical means. The use and creation of energy also have unique environmental problems that directly affect the personal values and physical conditions of humans, the quality of our air and water, and indirectly affect the economic conditions of business and industry. To teach technology, void of these impacts, would demonstrate a lack of sensitivity for the technology consumer. Yet, there are many positive aspects of technology that must also be pointed out to students. People live longer because of improved medical technology and they eat better because of household mechanization. A quality Technology Education program must address both positive and negative outcomes as they relate and interface with the areas of Bio-related, Communication, Production, and Transportation Technology. This program must contrast these issues against the personal values, norms, ethics, and beliefs of society over the context of time and it must provide insight for decision making and technological problem solving now and in the future.

Few outputs of technological ventures are completely within the taxonomy of one of the implementation organizers of technological knowledge. For example, the artificial heart, although clearly a bio-related technological product, is in fact a manufactured device within the production technologies. Students should feel comfortable about crossing over technologies and using technological knowledge to create new models and integrated concepts.

Research tools should be used by students to determine the trends, impacts, opinion, and judgement regarding technological ventures. These students should also be able to plan, organize, actuate, and control technological ventures as part of their learning experience.

Practical Implications for the Study of Technology

An analysis of the characteristics of the nature of technology and technological knowledge provides insight into practical implications for the study of technology. Those implications are:

1. Laboratory activities should be an integral part of any curriculum addressing technology. For an accurate understanding of technology as a human/cultural activity, knowledge alone is a necessary, but not sufficient, component. By "doing" technology, students will come to understand the nature of the enterprise, its methodology, and guiding principles. However, hands-on experiences alone will fail to reveal technology to the fullest extent. A well-balanced curriculum also provides experiences to articulate the cognitive dimension of technology.
2. Technological knowledge must be integrated with laboratory activities. The curriculum content and laboratories must distinguish technological knowledge from scientific knowledge and show the regions of overlap where the two form a symbiotic relationship. Well-designed activities will reveal the unique character and structure of technological knowledge, emphasizing the intellectual and practical richness of its content.
3. Technological objects, artifacts, and systems are created within specific environments. Stress should be placed on identifying the historical, environmental, and cultural contexts which give rise to the object or system. Much of the final configuration, performance, and purpose of technological objects and systems are influenced and determined by this context; objects and systems are connected in profound ways to non-technical forces.
4. Technology should be distinguished from science by making very clear the differing purposes each serves. Technology is oriented toward creating a pragmatic object or

system to meet a specific human need. The success or failure of technology is usually determined by societal acceptance and success in the marketplace. Science aims at understanding the natural world, toward explaining natural phenomena, and developing theoretical knowledge, while technology is a study of the human-made world. The success of science is not judged by social utility, as is the case with technology.

5. Finally, the role of human will in the design and creation of technological objects should be acknowledged. Curriculum activities will be enriched by asking questions about the motivation for creating objects and systems and speculating about the reasons for selecting performance criteria, materials, and processes.

(Frey, 1989).

SECTION IV
APPLICATIONS OF THE CONCEPTUAL MODEL

The Pluralistic Nature of the Instructional Process

There are many approaches to the teaching of technology. These approaches are highly influenced by a teacher's beliefs about the purpose of education. These beliefs can be classified as "academic rationalism," "technical proficiency," "intellectual processes," "social problems," and "individual needs" (Zuga, 1986; Herschbach, 1989). Prioritizing any one of these will lead the teacher to conceptualize content in different ways. For example, the "academic rationalist" would organize and teach content according to categories which follow rules of logic and the result might look like the *Jackson's Mill Industrial Arts Curriculum Theory* adaptive systems categories of Construction, Manufacturing, Transportation and Communication. On the other hand, the "intellectual processor" would prioritize the problem-solving process as a way of organizing instruction and content categories would become secondary. A teacher who prioritizes social problems might organize content based on contemporary societal concerns such as the interface of humans and their "bio-related systems," with particular concerns for problems which result from that interface. Due to this variety of educational beliefs, and the lack of a universally accepted instructional method in Technology Education, plurality is inherent within the field. This peculiarity creates many options for the instructional organization of Technology Education. Figure 4–1 shows this relationship across several bodies of knowledge.

	SCIENCE	TECHNOLOGY	ARTS/HUMANITIES	
INDIVIDUAL NEEDS	NUTRITION	RESEARCH AND DEVELOPMENT	CIVIC RESPONSIBILITY (VOTING)	CREATIVE WRITING PAINTING
SOCIAL PROBLEMS	ENVIRONMENTAL STUDIES	ENERGY EFFICIENCY	GLOBAL STUDIES	VALUES CLARIFICATION CENSORSHIP
ACADEMIC RATIONALISM	CHEMISTRY	PROCESSING	HISTORY	ENGLISH LITERATURE MUSIC THEORY
TECHNICAL PROFICIENCY	MATHEMATICS	MANUFAC-TURING	DEMOGRAPHICS	JOURNALISM PHOTOGRAPHY
INTELLLECTUAL PROCESSES	HYPOTHESIS GENERATION	INVENTION	TECHNOLOGY ASSESSMENT	ART APPRECIATION EPISTEMOLOGY

EXAMPLES OF EDUCATIONAL PHILOSOPHY AND BODIES OF KNOWLEDGE
FIGURE 4-1

The Dynamic Nature of the Study of Technology

The nature of our technological society is marked by unrelenting change, so much so that some social critics question humankind's ability to cope. Thus technology, for all its benefits, poses social dilemmas and at times we may believe that, at best, we can only endure its vagaries. And yet technological activity is vital to growth and the influences of growth; perhaps inevitable, as the world must support a burgeoning population. Therefore, each person must understand and contribute to the evolution of technology in society because what is imagined and considered controls our society, and the control of technology must be informed and value-based. Only then will technology truly serve the society from which it is generated.

Technology education is a dynamic, action-oriented program. Thus the curriculum framework must be able to represent its dynamism. The program must engage the learner in the technological method by combining technological resources with knowledge and systems to derive solutions in the context of history, culture, and the environment. This process can be used to understand technological activity at any point in time.

Suggestions for Program Development

As our technological world continues to exceed our imaginations on many fronts, those persons responsible for curriculum leadership are faced with real dilemmas regarding the relevance of curriculum context and the efficiency of the delivery mechanisms. Although it is easy to rely on instructional technology such as the computer and video disks to facilitate instruction, the issue begs for more than new instructional technology. This conceptual framework reflects a different approach to both context selection and the process involved in teaching and learning.

Addressing Student Needs

Historically, technology education teachers have been responsive to meeting the unique needs of a variety of learners. Male and female students with hearing, visual, and physical impairments; learning and behavioral disorders; superior intellectual functioning (gifted and talented); limited intellectual potential (slow or retarded); those who are at risk of dropping out of school, as well as average students, all have benefited from technology education. As the content base for technology education becomes more complex, technology educators need to ensure that they are providing quality instructional programs for all learners, including those with unique learning needs.

Tomorrow's technology educators must mirror a commitment to diversity and dedication to a full and informed life for all students. The justifications that bring this vision to life face an historical challenge to educate all of our children and to prepare schools and teachers to do this. These schools must mirror both our society's diversity and its essential and necessary commitment to learning. This urgent need to recruit, prepare, and retain significantly more successful technology education teachers who represent diversity is clear and is evidenced in a variety of ways. For example, public school enrollment is projected to be one-third minority by the year 2000. Yet, only 5% of public school teachers are Black and only 2% are Hispanic.

Technology education must also strengthen its commitment to serving a more equitable number of females in both teacher preparation and in its elementary and secondary programs. Clearly, emancipatory movements over the last two decades have allowed women access to non-traditional career paths predicated on the knowledge and effective use of technological systems. Technology education teachers and teacher educators must address issues of open access and gender neutrality when planning and implementing the ideas contained in this document.

The instructional content and methodology of technology education courses satisfies the diverse learning styles of a wide variety of learners. Understandably, most technology education teachers may be anxious about working with a diverse student population. While it is difficult to generalize, it has been the experience of many successful technology education teachers that typical technology education instructional techniques lend themselves quite well to a variety of learners. The emphasis on having students assume responsibility for their learning, "learning by doing," teaching through demonstration and modeling, and organizing instruction in step-by-step procedures in a logical sequence of events helps to improve a student's ability to conceptualize and "imitate" observed responses.

The technology education laboratory is unique because students have opportunities to use a variety of learning styles. It facilitates the development of cognitive skills and improves self-perception, and can aid in the personal/social development of all learners.

If we do not tap the potential of all learners, we fail to develop and utilize a substantial portion of our human resources. Our society's continued economic growth and national security depend upon the intellectual development and productivity of all citizens. Therefore, it is imperative that technology educators ensure that every student is prepared with the skills necessary to make a meaningful contribution to society and self.

Methodological Characteristics of a *Quality Technology Education Program*

In order for successful technology education programs to flourish, the following methodological approaches are suggested:

1. Emphasis should be placed on problem solving as a delivery method.
2. Exploratory activities should include modeling, graphing, etc.
3. Instruction should be goal-oriented and hypothesis driven.
4. Cooperative learning and small group interaction should be encouraged.
5. There should be a high level of verbal activity.
6. Student cognitive strategies should be developed.
7. Emphasis should be placed on cross disciplines and inter-technology activities.
8. A broad range of assessment strategies (design portfolios, project work, individual and group work, performance testing) should be used.

Content Characteristics of a Quality Technology Education Program

At all levels, the program/course content for technology education should be based on:

1. An organized set of concepts, processes, and systems that are uniquely technological.
2. Fundamental knowledge about the development of technology and its effect on people, the environment, and culture.
3. Instructional content drawn from one or more of the following areas:
   (a.) *Bio-related*—Efficiently using biological organisms to make or modify products.
   (b.) *Communication*—Efficiently using resources to transfer information to extend human potential.
   (c.) *Production*—Efficiently combining and modifying resources into standard stocks, goods, and structures.
   (d.) *Transportation*—Efficiently using resources to obtain time and place utility and to attain and maintain direct physical contact and exchange among individuals and societal units through the movement of materials/goods and people.
4. Assisting students in developing insight, understanding, and application of technological concepts, processes, and systems.
5. Applying tools, materials, machines, processes, and technical concepts safely and efficiently.
6. Developing student skills, creative abilities, positive self-concepts, and individual potentials in technology.
7. Developing student problem-solving and decision making abilities involving human and material resources, processes, and technological systems.
8. Preparing students for lifelong learning in a technological society.
9. Activity-oriented laboratory instruction with students reinforcing abstract concepts with concrete experiences.
10. A combined emphasis on "know-how" and "ability to do" in carrying out technological work.

Selecting Technology Education Activities

The model of technology education which is presented in this document signals a shift in emphasis in the way in which technology education should be taught. A stronger emphasis is being placed upon technological method as an integral part of teaching in this area. The model focuses on human problems with respect to technology. It is hoped that educators will incorporate problem solving, as well as viable alternatives, when teaching technology education.

Choosing appropriate teaching strategies can increase the possibility of meeting technology education goals and objectives. Goals, as intended outcomes of technology education, do not stand apart from methods of teaching. Goals guide the selection of teaching methods. For example, if a teacher determines that problem solving is an appropriate goal of technology education, he or she could support that goal by using problem solving for instructional delivery.

Activities at various levels of technology education must vary due to the educational focus of the curriculum. For example, in elementary grades, where emphasis is placed on fundamentals, technology must be incorporated or infused into the curriculum using a thematic approach or via the delivery of topical information that relates to other subject areas.

The thematic approach is also appropriate for the middle grades. Other possibilities at this level include the modular approach, where an activity relates a specific objective and is reasonably self-contained, or the problem solving/design brief approach, where students are given problem parameters and are then required to use the technological method to solve the problem.

All of the previous mentioned approaches are appropriate for technology education at the secondary level. The only limitation is semester scheduling which may lend itself to self-contained semester-long courses. The technology teacher must realize that, within these semester courses, students can address thematic, modular or problem-solving tasks or opportunities.

A Process Model for a Course of Study

In order to develop curriculum that is accountable to all constituents, it is imperative that a process be followed that will exhibit consistency and continuity. Although most curriculum ventures begin with a review of the school district's philosophy, in reality little can be done to modify that document. This is as it should be because the district philosophy refers to the entire district's rationale and goals. It sets the tone for the education of all students, and should be the benchmark from which all curriculum is generated.

Curriculum development follows a process which begins with the development of a program philosophy, generates program goals and objectives, creates subject objectives, and places this information into a scope and sequence. Each component of the process is described and exemplified as follows:

Program Philosophy

The program philosophy is a written statement that expresses the program's (area of study, such as technology education, mathematics, social studies, etc.) educational purpose based on the school district's philosophy. A sample program philosophy follows:

Program Philosophy for Technology Education

Technology education should provide students of all grades, abilities and backgrounds with technological knowledge, skills, and attitudes necessary to become competent, contributing, and productive members of society. Through experiences in a "hands-on" cooperative environment using a systematic, problem-solving approach, students should exhibit understanding of all domains relating to technology. Technology education should allow for the interaction of the business and industrial community with students, and encourage programs to enhance skills and understanding regarding occupational productivity, personal responsibility, and career opportunities in the community and world society.

Program Goals

Program goals are broad statements regarding an area of study (a program) which define the overall nature and content of the various aspects of the program philosophy. Examples of program goals are:

Program Goals for Technology Education

In consideration of the stated program philosophy, the goals of the technology education program are to provide technologically literate individuals who are capable of:

1. Utilizing technology to solve problems or meet opportunities to satisfy human needs and wants.
2. Recognizing that problems and opportunities exist that relate to and often can be addressed by technology.
3. Identifying, selecting, and using resources within to create technology for human purposes.
4. Identifying, selecting, and efficiently using appropriate technological knowledge, resources, and processes to satisfy human wants and needs.
5. Evaluating technological ventures according to their positive and negative, planned and unplanned, and immediate and delayed consequences.

Program Objectives

Program objectives are broad outcome statements derived from a program goal. The sum of a series of program objectives should reflect the respective goal statement. A sample of some program objectives relative to a specific program goal follow:

Program Objectives for Technology Education

Consistent with the approved program goals for technology education, the program objectives are as follows: Goal Statement:

4.0 Identifying, selecting, and efficiently using appropriate technological knowledge, resources, and processes to satisfy human wants and needs.

Objective Statements

4.1 Explore and experience how people use technology to solve problems.

4.2 Demonstrate how resources are processed using the basic systems concept.

4.3 Solve problems using a systems approach.

4.4 Develop creative solutions to present and future societal problems.

4.5 Demonstrate the safe and efficient use of tools, materials, machines, processes, and technological concepts.

4.6 Demonstrate a concern for the environmental impact of the creative problem-solving techniques which they develop.

4.7 Conduct an assessment of the techniques/solutions which they develop using ethical principles.

Subject Objectives

A subject is a subdivision of a program organized by grades at the elementary level and by units, modules, or courses at the middle and secondary grades. Subject objectives are specific learning objectives based on a program objective. The sum of a series of subject objectives should reflect the respective program objective. Examples of subject objectives relative to a specific program objective follows:

Program Objective

4.1 Explore and experience how people use technology to solve problems.

Subject Objective

4.1.1 Recognize that there are formalized methods (systems) used to solve problems or make decisions.

4.1.2 Recognize that compromise is sometimes necessary in order to solve problems.

4.1.3 Use modeling techniques in problem solving.

4.1.4 Recognize the limitations of technology in solving problems.

Scope and Sequence

After the program philosophy, program goals, program objectives, and subject objectives have been formulated, a scope and sequence must be developed. This process enables school planners to identify content (scope) of a program at each level (sequence) of instruction. More specifically, scope refers to the breadth and depth of a program as defined by the program and subject objectives. Sequence refers to the arrangement of program and subject objectives in hierarchical order.

Each page of a Scope and Sequence sheet focuses on subject objectives for a specific program objective. Each subject objective is also coded according to learner expectations in a kindergarten through adult program. The terms used for the coding are as follows:

Awareness: The process of discovering a situation or object, without direct attention to it or definition of the knowledge of its nature.

Orientation: The process of seeking or discovering insight into a situation or object through learning or activity.

Exploration: The ability to comprehend and respond to information and/or process resulting in growth or change in the student's learning structure.

Mastery: The internalization of content to a sufficient level to enable the natural application of the subject matter.

Upgrading: The process of lifelong learning to facilitate the improvement of knowledge, skills, and attitudes within a subject area.

A sample Scope and Sequence sheet follows on the next page.

TECHNOLOGY EDUCATION SCOPE AND SEQUENCE

PROGRAM GOAL: 4.0 Identifying, selecting, and efficiently using appropriate technological knowledge, resources, and processes to satisfy human wants and needs.

PROGRAM OBJECTIVE: 4.1 Explore and experience how people use technology to solve problems.

CODE

A = Awareness
O = Orientation
E = Exploration
M = Mastery
U = Upgrading

SUBJECT OBJECTIVES Students should be able to:	LEARNING EXPECTATIONS			
	Elementary	Middle Grades	Secondary	Post Secondary
4.1.1 Recognize that there are formalized methods (systems) used to solve problems or make decisions.				
4.1.2 Recognize that compromise is sometimes necessary in order to solve problems.				
4.1.3 Use modeling techniques in problem solving.				
4.1.4 Recognize the limitations of technology in solving problems.				

SECTION V
IMPLICATIONS AND RECOMMENDATIONS

A New Departure

We, the people of the United States, are in the midst of critical transition: out of an era of manual-based production into a new era in which information-based service is a wealth-producing economic activity. In this new era, knowledge is a strategic resource, technical professionals are strategic workers, and education—as the conveyor of knowledge—is a strategic industry. To achieve its goal of providing our people with requisite knowledge and skills for living and earning their livelihoods in this new era, education must include technology within its curricula. To achieve necessary productivity and quality in conveying necessary knowledge and skills, education must use technology as a principal means. Finally, for technology to become both a greater subject of education and a greater tool in education, technology education must adopt an agenda for change and lead the way to its accomplishment (Swyt, 1987).

The new departure for technology education is "process education" using the technological method. It requires students to think and act in a systematic fashion when solving problems. It requires teachers to think and act as facilitators of instruction rather than as subject-centered specialists. The resulting environment is one that encourages both divergent thinking as well as convergent thinking; a solution based on a methodological process rather than objective view; and a thought-and-action process that reaches to the higher levels of the domains of learning.

Challenge to Change Curriculum Paradigms

Our educational programs are fraught with rules and regulations that define program boundaries. The educational institution is one of the last bastions of "isolationalism" in our culture. Process education using the technological method encourages major shifts from content or subject-matter-based teaching and learning to a variety of educational opportunities and experiences for students such as thematic learning, problem solving, modular instruction, integrated learning, and cooperative learning. A curriculum model that addresses the content components identified in this document will influence the selection of alternative schemes for the learners' environment (the laboratory) and the learners' context (the course structure). The dynamic nature of technology education should reflect the dynamic world of technology.

Recommendations

As our world becomes increasingly more technological, and our learners require the ability to make decisions based on intellectual rather than emotional criteria, technology education should enjoy greater visibility. In preparation for this inevitability, the following recommendations are presented:

1. The study of technology is best accomplished through a multi-disciplinary approach. Other academic disciplines and their respective professional associations are encouraged to join those in technology education in providing technology literacy and capability at all levels.
2. A technologically literate population is essential for economic vitality. Business and industry are encouraged to join technology educators in developing and delivering programs in technology education.
3. The need for additional research in the field is critical. Technology educators should embrace research activities which identify and validate content structures and teaching strategies for technology education.
4. Technology education is an emerging discipline. Political decision makers, governmental agencies, and business/industry are encouraged to support financially research, curriculum innovation and program implementation in technology education.
5. Technology education provides essential knowledge at all levels of society. State and local educational institutions and agencies are encouraged to develop and implement curricula based on the concepts in this document.
6. Technology education can provide a foundation for an increasingly technologically capable work force. Technology educators should contribute to the technical preparation efforts through the community college level and at four-year institutions.
7. Technology education engages students in the active application of knowledge. Technology educators are encouraged to join others in educational research to determine the contribution of technology production to the cognitive, psychomotor, and affective development of learners.
8. Technological literacy and capability are essential to every individual's ability to contribute to society. Educators and political decision makers are invited to work together to ensure that all students engage in studying technology at all levels of public education.
9. All students need to be technologically literate and technically capable. Elementary school administrators and teachers are challenged to work with technology educators in developing and presenting integrated learning activities based on technology.

A Proposed Research Agenda for Technology Education

One of the functions of a conceptual model is to direct attention to areas where research is needed. The results of the research should further refine the conceptual model and enhance both teaching and learning in technology education. To those ends, a number of research areas or topics are presented. It must be emphasized that these are not researchable problems; rather they are broad research areas under which might fall many researchable problems.

1. What is technological literacy and how is it enhanced in various curriculum areas?
2. Does technology education contribute to later success in life?
3. What are the long-term effects of technological content and methodology on teachers, students, and society?
4. How does technology education contribute to the affective development (attitudes about self, schooling, technology, etc.) of students?
5. What types of pre-service and in-services programs develop effective technology education teachers?
6. What kinds of cognitive strategies (thinking, problem solving, etc.) are used by students in technology education classes?
7. What are the dynamics of various teaching strategies (small group, problem solving, etc.) used in technology education?
8. What types of laboratory facilities are needed to deliver effective technology education instruction?
9. What techniques are effective in recruiting students to enter technology education as a career?
10. How does using tools and materials enable students to learn more, better, or differently about technology than could be learned in a program of didactic instruction?

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